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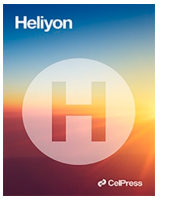

Research article

The contribution of household income to rectal cancer patient characteristics, treatment, and outcomes from 2010 to 2020

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ABSTRACT

Background: There is a paucity of recent literature investigating the sole effect of income level on the treatment and survival of patients with rectal cancer.
Methods: We analyzed all cases of rectal cancer in the Rectal Cancer PUF of the NCDB from 2010 to 2020. We utilized the Median Income Quartiles 2016–2020 to define our income levels. The two lower quartiles were combined to create a lower income group, with the upper two quartiles creating the higher income group. The total cohort included 201,329 patients, with 116,843 and 84,486 in the higher and lower income groups, respectively.
Results: Lower income patients were more often black (17 % vs 6 %), lived farther from the nearest hospital (33.5 miles vs 25.7 miles) despite being more likely to live in urban areas (25 % vs 7 %), and had lower levels of private insurance (36 % vs 49 %). They underwent more APRs (17 % vs 14 %) and had a 13 % higher chance of undergoing an open operation (OR 1.13, CI 1.09–1.17). Higher income patients had a 12 % reduction in 90-day (OR 0.88, 95 % CI 0.82–0.96) and overall mortality (OR 0.88, 95 % CI 0.86–0.89).
Conclusions: Clinicians should be aware that lower income patients are often faced with unique challenges that may impact care delivery.

1. Introduction

Rectal cancer affects more than 40,000 people annually in the United States [1]. Historically, the primary management of this type of cancer was surgical, but advancements in anatomical and oncologic knowledge have shifted treatment towards a more systematic approach [2]. Despite these advancements, significant disparities still exist in the field of rectal cancer, including a decreased median survival in racial and socioeconomic minorities and higher stage at diagnosis in black patients [3,4]. In patients younger than 50 with rectal cancer, it has been shown that black patients have worse overall survival [5].

Low-income level is associated with an advanced stage at time of diagnosis and with differences in treatment selection in prostate cancer and with higher 30-day and 90-day mortality in patients with gastric cancer [6,7]. Additionally, higher income mobility has been associated with a decrease in hazards of death for both black and white patients, and low income has been associated with higher

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suicide rates after cancer diagnosis [8,9]. These studies show that income level impacts outcomes in cancer patients. However, there is little data exploring this topic in rectal cancer.

The National Cancer Database (NCDB) is a clinical oncology database operated by the American College of Surgeons Commission on Cancer (CoC) and the American Cancer Society. It is a hospital-based clinical cancer registry established in 1989 that collects data from more than 1500 hospitals in the United States, capturing more than 70 % of all newly diagnosed cancers [10]. Thus, it is an established and extremely important database used to assess treatment and outcome variables in various cancers.

Although racial and socioeconomic disparities in rectal cancer have been researched, there exists a need to perform a more thorough analysis of socioeconomic factors such as income level and its impact on patient and clinicopathologic characteristics of rectal cancer is needed. Using the NCDB, we set out to elucidate the effect of annual income on rectal cancer care and outcomes.

2. Materials and methods

2.1. Data source

All cases of rectal cancer recorded in the Rectal Cancer Participant User File (PUF) of the National Cancer Database (NCDB) from 2010 to 2020 were used in our analysis. The Rectosigmoid Junction PUF was not included. We utilized the Median Income Quartiles 2016–2020, which is derived from 2020 American Community Survey data. The two lower quartiles were combined to create a lower income group, with the upper two quartiles creating the higher income group. All income inputs are normalized to 2020 inflation levels, regardless of the year that patients were diagnosed with rectal cancer.

2.2. Variables

The other variables were grouped as follows, based on the codes provided in the NCDB PUF Data Dictionary 2020 [11]. For Race, we combined codes 4–97 as Asian/Pacific Islander. For Primary Payor at Diagnosis, we combined 2–4 as Government Insured. For Urban/Rural 2013, we combined 1–3 into metro, 4–7 into urban, 8–9 into rural. For Surgical Procedure of Primary Site, using NCDB Appendix A, we grouped codes 20–28 as local excision, 30 as low anterior resection (LAR), 40 as coloanal, 50 as abdominoperineal resection (APR). For Approach – Surgery of the Primary Site at this Facility, we combined 1&3 into a minimally invasive surgery group, and 2, 4 & 5 into an open surgery group. For Readmission to the Same Hospital within 30 Days of Surgical Discharge, we combined 0&2 into a No group and 1&3 into a Yes group. For Immunotherapy, we combined 00, 85, 86, 87 into a No group. For Palliative Care, we combined 1–6 into Yes group.

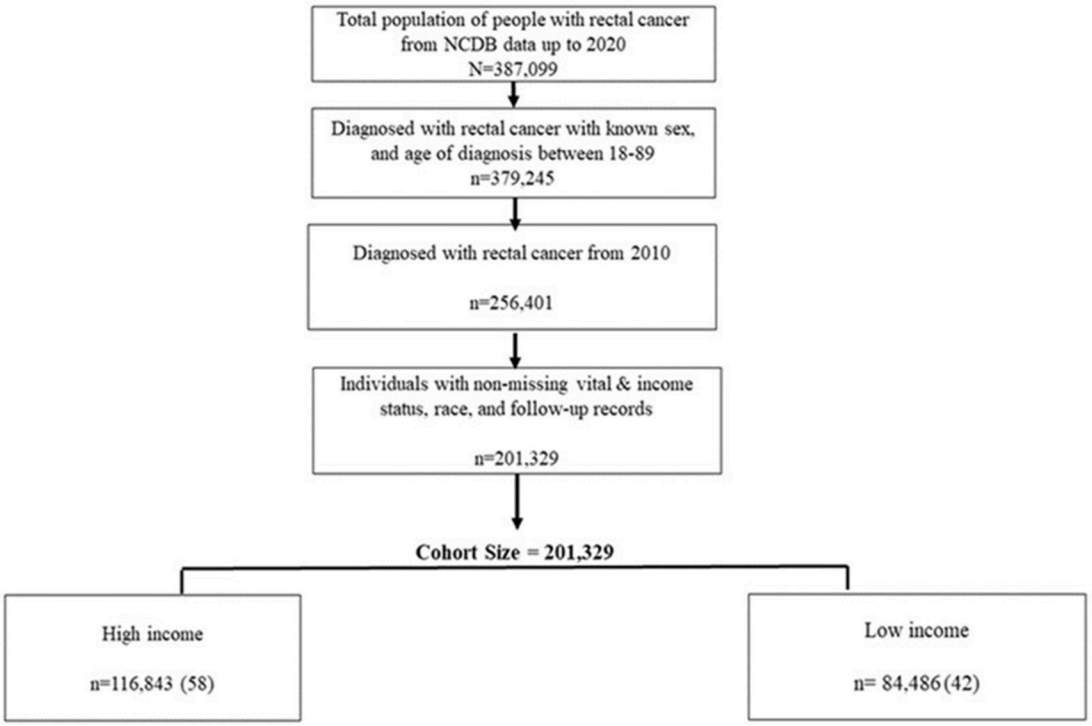

Fig. 1. Flowchart of patients selected for inclusion in the final analysis.

2.3. Statistical analysis

Baseline characteristics were summarized separately by household income levels as number (%) and mean (SD). The summary measures of the baseline characteristics were compared between low- and high-income households using two sample *t*-test or Wilcoxon rank sum test for continuous variables and chi-square test of Fisher exact test for categorical variables. Flexible parametric survival models [12] were used to quantify the relative risk of overall deaths between income levels, while logistic regression models were used to assess the associations between income levels and 90-day mortality, surgery (minimally invasive), and surgical procedure (APR). These models were adjusted for age, sex, race, distance from hospitals, high school degree, facility, insurance, CDC scores, stage, and other model specific covariates. The best fitted model was chosen using Akaike information criteria (AIC). Results from these models were expressed as hazards ratio, HR (95 % CI) for survival models and odds ratio, OR (95 % CI) for logistic regressions and displayed as forest plots. All analyses were done using SAS 9.4 (SAS Institute, Inc., Cary, NC) and R 4.2.2 and conclusions made at 5 % significance.

3. Results

3.1. Study cohort

The total cohort after excluding those with missing data included 201,329 patients, with 116,843 and 84,486 in the higher and lower income groups, respectively (Fig. 1). There was no difference in baseline age or gender between the groups (Table 1).

3.1.1. Baseline characteristics

Patients in the lower income group were more often black (17 % vs 6 %, $p < 0.0001$), lived farther from the nearest hospital (33.5 miles vs 25.7 miles, $p < 0.0001$) despite being more likely to live in urban areas (25 % vs 7 %, $p < 0.0001$), had lower levels of private insurance coverage (36 % vs 49 %), and more often came from areas where greater than 17.5 % of the population had no high school diploma (44 % vs 8 %, $p < 0.0001$). Interestingly, there was no appreciable clinical difference in NCDB Analytical Stage Group >2 (41 % vs 40 %), Charleson-Deyo score >2 (3 % vs 3 %), surgical inpatient length of stay (5.1 vs 5.6 days), 30-day readmission (4 % vs 4 %), positive regional nodal status (32 % vs 32 %), or metastasis at diagnosis (Table 2). Despite this, lower income patients underwent more APRs (17 % vs 14 %), were overall less likely to have a minimally invasive operation (52 % vs 58 %), and had a higher overall last-contact mortality (41 % vs 35 %).

4. Association of income level and outcomes

When controlling for potentially confounding variables via logistic regression, patients in the high-income group had a 12 % reduction in both 90-day mortality (OR 0.88, 95 % CI 0.82–0.96) and overall mortality (OR 0.88, 95 % CI 0.86–0.89). Additionally, these patients had a 13 % higher chance of undergoing a minimally invasive operation versus an open operation (OR 1.13, CI 1.09–1.17). They also had a 3 % reduction in the likelihood of undergoing an abdominoperineal resection indicating a trend towards differences in major surgical selection, though this was not statistically significant (OR 0.97, CI 0.94–1.01)(Fig. 2).

5. Discussion

Socioeconomic status (SES) is the position of an individual or group on the socioeconomic scale, which is determined by a combination of social and economic factors such as income, amount and kind of education, type and prestige of occupation, place of residence, etc. The relationship between SES and health has been studied for many years and has been shown to have a profound impact on both physical and mental health [13]. The mechanism by which these interact is debated, with some arguing that differences in SES are to blame for health inequalities while others believe that those in good health tend to have more social mobility and therefore achieve a higher SES [14]. No matter the cause-and-effect relationship, patients with low SES inevitably have decreased health-related and overall quality of life [15].

Low SES is known to contribute heavily to a wide variety of medical comorbidities including nicotine dependence, dementia, and cardiovascular disease [16–18]. This makes inherent sense, as those of lower means face difficulties obtaining access to preventive healthcare and healthy lifestyle choices that are protective against chronic conditions. However, as our study explores, it has been shown in recent years that surgical outcomes are also influenced by patient SES. Low income is associated with worse postoperative

Table 1
Baseline patient characteristics.

Variables	Overall	High income	Low income
N (%)	201,329	116,843 (58)	84,486 (42)
Age (years)	62.2	62.1	62.5
Male	119,359 (59)	69,071 (59)	50,288 (60)
Race			
white	166,963 (83)	100,747 (86)	66,216 (78)
black	22,143 (11)	7428 (6)	14,715 (17)
Asian/Pacific Islander	12,223 (6)	8668 (7)	3555 (4)

Table 2
Variables compared between the 2 groups.

Variables	Overall	High income	Low income
N (%)	201,329	116,843 (58)	84,486 (42)
Distance from Hospital (miles)	29	25.7	33.5
Follow-up (months)	48.7	50.1	46.7
Facility Type			
Community Cancer Program	15,598 (8)	7981 (7)	7617 (9)
Comprehensive Community Cancer Program	74,904 (37)	42,489 (36)	32,415 (38)
Academic/Research Program	73,921 (37)	43,904 (38)	30,017 (36)
Integrated Network Cancer Program	36,906 (18)	22,469 (19)	14,437 (17)
Insurance type			
uninsured	8046 (4)	3413 (3)	4633 (5)
private	87,816 (44)	57,079 (49)	30,737 (36)
government	105,467 (52)	56,351 (48)	49,116 (58)
Percent No High School Degree			
≥17.6 %	45,875 (23)	8964 (8)	36,911 (44)
10.9–17.5 %	53,415 (27)	21,849 (19)	31,566 (37)
6.3–10.8 %	55,618 (28)	41,970 (36)	13,648 (16)
<6.3 %	46,421 (23)	44,060 (38)	2361 (3)
Urban Rural			
metro	168,892 (84)	108,275 (93)	60,617 (72)
urban	28,656 (14)	7633 (7)	21,023 (25)
rural	3781 (2)	935 (1)	2846 (3)
CDC Score			
0	154,614 (77)	91,769 (79)	62,845 (74)
1	32,501 (16)	17,536 (15)	14,965 (18)
2	8613 (4)	4607 (4)	4006 (5)
3	5601 (3)	2931 (3)	2670 (3)
Regional Lymph Node Status			
negative	70,045 (68)	41,040 (68)	29,005 (68)
positive	32,614 (32)	19,122 (32)	13,492 (32)
NCDB Analytic Stage Group			
0	11,106 (6)	6828 (6)	4278 (5)
1	51,557 (26)	30,874 (26)	20,683 (24)
2	56,690 (28)	31,865 (27)	24,825 (29)
3	50,429 (25)	29,633 (25)	20,796 (25)
4	31,547 (16)	17,643 (15)	13,904 (16)
Surgical Procedure of Primary Site			
local excision	36,645 (27)	22,090 (27)	14,555 (26)
LAR	71,778 (52)	42,789 (53)	28,989 (52)
coloanal	7087 (5)	4179 (5)	2908 (5)
APR	21,312 (16)	12,091 (14)	9221 (17)
Approach – Surgery of the Primary Site at this Facility			
minimally invasive	70,901 (56)	43,908 (58)	26,993 (52)
open	55,919 (44)	31,229 (42)	24,690 (48)
Surgical Inpatient Stay (days)	5.3	5.1	5.6
Readmission to the Same Hospital within 30 Days of Surgical Discharge			
no	193,921 (96)	112,693 (96)	81,228 (96)
yes	7408 (4)	4150 (4)	3258 (4)
90-day Mortality			
no	198,253 (98)	115,208 (99)	83,045 (98)
yes	3076 (2)	1635 (1)	1441 (2)
Overall Mortality			
no	126,199 (63)	76,052 (65)	50,147 (59)
yes	75,130 (37)	40,791 (35)	34,339 (41)

survival in patients with peripheral artery disease and abdominal aortic aneurysm [19]. It also increases the likelihood of serious complications. Rates of bleeding, intubation, and surgical site infection have all been seen to be higher in socioeconomically disadvantaged patients [20]. Our manuscript highlights that even the surgical procedures and approaches performed on patients appear to be different depending on the income range in which they reside.

It is often argued, and reasonably so, that at least a portion of the variation in outcomes in low-income patients is attributable to delayed presentations and more advanced disease processes necessitating higher risk operations [21]. Interestingly, our study showed no difference in NCDB Analytic Stage Group, Charleson-Deyo score, regional nodal status, or metastasis at diagnosis between the two groups to account for the variation in surgical procedures and surgical outcomes. This suggests that being part of the low SES group may somehow itself impact surgical care and recovery. How exactly it plays this role is yet to be elucidated.

Rectal cancer has a relatively complex, and often multidisciplinary, treatment planning strategy. This may put patients diagnosed with rectal cancer at increased risk of experiencing a varied quality of care based on socioeconomics. This is supported by a recently conducted meta-analysis showing that rectal cancer patient survival after surgical resection may be driven by race along with facility

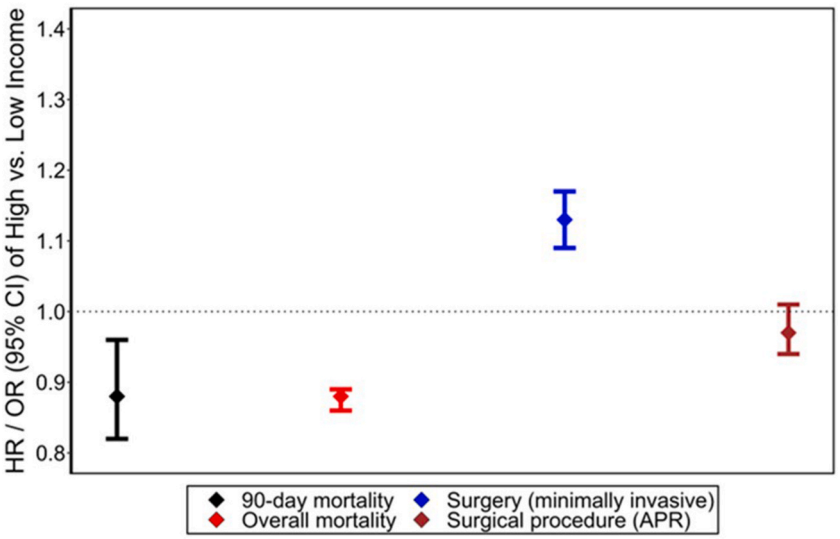

Fig. 2. The effect of higher income on various patient outcomes.

characteristics and socioeconomic variables [22]. While our analysis also noted differences between racial groups, we were able to show, by controlling for these confounding variables, that yearly income alone affects surgical planning and outcomes.

Income level, which was the SES marker we evaluated in this study, was shown to impact patients diagnosed with rectal cancer. By controlling for other available variables within the NCDB via regression analysis, we are able to show that income itself independently contributes to these negative outcomes. Income level could be a surrogate indicator of a variety of experiences and environment: chronic stress from living paycheck to paycheck, poor nutritional status due to inability to afford quality food, difficulty attending medical appointments, etc. Further detailed, non-database research focusing on individual patients will be required to understand the unique role income level has on their medical care.

One potential way to lessen the effect of income on the survival of patients with rectal cancer could be to encourage more institutions to purse accreditation by the National Accreditation Program for Rectal Cancer (NAPRC). In order to achieve accreditation, a program must demonstrate high-quality cancer care and comply with established Commission on Cancer (CoC) and NAPRC standards. Compliance with these process measures has shown to confer a significant mortality reduction to patients with rectal cancer [23]. Our department previously developed an online REDCap database tool, which could make it easier for high-quality and high-volume programs and hospitals to become NAPRC-certified and, therefore, may help smaller organizations to deliver higher-quality care to low-income patients and possibly improve their outcomes [24]. Given the relatively recent establishment of the NAPRC, more long-term analysis will be needed to determine if this is the case.

There are limitations to this study. The main limitation of any study that uses the NCDB is that the cohorts are not population-based, but rather identified from the hospitals where they present for diagnosis and/or treatment, which somewhat limits generalizability. Additionally, there is a lack of clinically relevant endpoints like complications, surgical volume at the center each patient was treated, patient-reported outcomes, cause-of-death, local control, and disease-free survival [25]. However, given the extensive patient sociodemographic data captured from a large majority of all newly diagnosed cases of cancer in the U.S., the NCDB is a viable tool for studying income-driven effects on patients diagnosed with cancer.

6. Conclusions

Our current study shows that patient socioeconomic status, as defined by yearly income, affects patient treatment and outcomes in rectal cancer. Clinicians should be aware that lower income patients are often faced with unique challenges that impact care delivery and act accordingly.

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Data availability statement

Data associated with our study has not been deposited into a publicly available repository. Data will be made available on request.

CRediT authorship contribution statement

Matthew C. Moccia: Writing – original draft, Methodology, Investigation, Conceptualization. **James P. Waters:** Writing – original draft. **John Dibato:** Formal analysis, Data curation. **Yazid K. Ghanem:** Writing – review & editing. **Hansa Joshi:** Writing – review & editing, Conceptualization. **Zena B. Saleh:** Writing – review & editing, Conceptualization. **Helen Toma:** Writing – review & editing. **Danica N. Giugliano:** Writing – review & editing, Supervision. **Steven J. McClane:** Writing – review & editing, Supervision, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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